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TITLE: Web cleaning method

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A method of cleaning tissue webs in a rewinder utilize the **Coanda** effect to produce an improved tissue product. The **Coanda** effect web cleaner utilizes the smooth flow of a thin layer of air to scrub off dust and lint embedded and entangled in the web surface while stabilizing the web in its travel. Two of these **Coanda** effect web cleaners arranged on opposite sides of a multiple-ply web in a rewinder are effective when operated according to the method of the invention to produce a rewound tissue with an unexpectedly low loose dust and lint count on its surfaces.

It is also known to employ the **Coanda** effect to dry tissue webs and to remove dust and other particulate materials clinging to tissue webs in the tissue forming machine. The Lindstrom U.S. Pat. No. 4,247,993 and the Lepisto U.S. Pat. No. 4,932,140 describe **Coanda** effect airflow used in drying. The Overly U.S. Pat. No. 3,587,177 employs the **Coanda** effect for web cleaning, although without using the term "**Coanda**". Recently, Thermo Wisconsin, Inc., a Wisconsin company, has manufactured and sold a device called a FiberMaster web cleaner which employs the **Coanda** effect to control airflow for web cleaning. The FiberMaster web cleaner is constructed and operates substantially along the lines disclosed in the Pollack U.S. Pat. No. 5,466,298 and U.S. Pat. No.

5,577,294. It employs a **Coanda** effect nozzle and stepped airfoil to direct a turbulent stream of air in counterflow to the boundary layer of air accompanying the tissue on one side of the tissue. FiberMaster web cleaners are normally used in tissue reeling operations and utilize air pressures of 20 inches H.sub.2 O or less. Yet another web cleaner employing the **Coanda** effect is disclosed in the Horn U.S. Pat. No. 5,490,300.

An object of the present invention is to provide an improved **Coanda** effect web cleaner for removing dust and lint from a web of tissue during the manufacture of facial tissues or the like.

Another object is to provide a **Coanda** effect web cleaner for removing dust and lint from a web of tissue wherein air, dust and lint flow into an exhaust plenum in a controlled and improved manner.

Still another object is to provide a **Coanda** effect web cleaner which stabilizes the web as it passes and prevents web pull-down into the exhaust area.

A further object is to provide a **Coanda** effect web cleaner and web cleaning system which find particularly advantageous application for removing dust and lint from a web of tissue in a rewinding machine.

The foregoing and other objects are realized in accord with the present invention by providing an improved **Coanda** effect web cleaner and system, a new and improved web cleaning method, and a resultant low dust and lint count tissue product. The improved **Coanda** effect web cleaner comprises an elongated, curved airfoil formed adjacent a narrow slit defining a **Coanda** nozzle out of which a jet of air is forced. The curved airfoil is a continuous,

uninterrupted surface extending from adjacent the slit to an exhaust outlet for the unit. From about 15 to 35 cfm of air per foot of slit length exits the slit, under a relatively low pressure of between 20 and 80 inches H.sub.2 O. The air exits the slit, which is 0.002 to 0.015 inches wide, in a thin layer and at a velocity of 18,000-34,000 fpm. The thin layer of air attaches to the airfoil surface as a result of the **Coanda** effect. As it does so, it scrubs away, and carries with it, the boundary layer of air which is traveling with an adjoining surface of a tissue web. This boundary layer air is laden with dust and lint. It also scrubs away dust and lint which is partially embedded, i.e., mechanically entangled, in the tissue surface. The **Coanda** effect air flow, with the dust and lint "scrubbed" from the web with the boundary layer, and with loose dust and lint physically pulled from the web surface, travels to the exhaust outlet along the airfoil surface and is drawn into an exhaust plenum.

A system of two of these improved web cleaners are mounted in a tissue web rewinding machine, one above and one below the web path. Each of these web cleaners includes a **Coanda** nozzle slit which is preferably 0.012 inches in width. According to the method of the invention, about 15 to 35 cfm of air per foot of slit under a pressure of between 20 and 80 inches H.sub.2 O in an air supply plenum is forced out of each slit next to the adjacent airfoil surface. The resultant air jets create thin, stable, non-turbulent layers of air which attach to respective curved surfaces, creating low pressure zones adjacent each nozzle which tends to draw the tissue web toward that nozzle. The air jet created layers, traveling at high exit flow velocities of 18,000-34,000 fpm, carry dust and lint to exhaust plenums from both surfaces

of the multiple-ply web in the rewinding machine. Meanwhile, slightly upstream of these air foil surfaces, each web cleaner has a web stabilizer airfoil which attracts and supports the moving web while preventing the web from being drawn far out of its path by the effect of the exhaust. The two web cleaners are offset from each other relative to web travel, the lower one being upstream, although they may be reversed or opposed to each other.

FIG. 1 is a schematic illustration of a tissue rewinding machine incorporating improved **Coanda** effect web cleaners in a system embodying features of the present invention;

FIG. 2 is a perspective view of an improved **Coanda** effect web cleaner embodying features of the invention, in operational position adjacent a tissue web in a rewinding machine, with an end plate shown in phantom lines;

Between the crimping station 13 and the slitting station 14, a system of improved **Coanda** effect web cleaners 20 and 120 embodying features of the invention are utilized, according to the invention, to remove loose dust and lint from the dry side surfaces of the web W2 and from the boundary layers of dust and lint laden air accompanying them. As will hereinafter be discussed in detail, the construction and arrangement of the system of web cleaners 20 and 120, and the method of cleaning the tissue web W2, are effective to remove substantial quantities of dust and lint from the web surfaces and, consequently, to improve the quality of facial tissue products. Accepted knowledge has been that downstream converting operations tend to create dust and lint, negating any benefits of cleaning the web in the rewinding operation.

Specifically, it was thought that the tissue being dragged across web handling
components downstream would create more dust and lint than could be removed
upstream. The system and method of the present invention have been able to
effect such substantial cleaning in the rewinder that an overall reduction
remains after downstream converting operations.

A **Coanda** nozzle 29 is formed along the length of the plenum 28, adjacent to and
overlooking the airfoil surface 25. The nozzle 29 is defined by a slit in the
plenum 28, immediately adjacent the wall 24. The slit 29 is 0.012 (.+-.0.0002)
inches in width along its entire length. In the web cleaner 20 illustrated,
the slit would be approximately 190 inches long.

The tissue web W2 travels on toward the airfoil surface 25. Air at a pressure
of 20-80 inches H.sub.2 O is supplied to the plenum 28 and about 15 to 35 cfm
of air per foot of slit 29 is forced out of the elongated **Coanda** nozzle slit 29
in a jet forming a thin layer of fast moving air. The thin air layer, which
extends the length of the nozzle slit 29 and is traveling at 18,000-34,000 fpm
away from the slit, attaches to the continuously curved airfoil surface 25.
Because of its high velocity there, the moving layer of air creates a low
pressure area adjacent the nozzle slit 29. This low pressure area causes the
web W2 to be drawn close to, but not into contact with, the nozzle slit 29.
The web W2 is stabilized across its width by this effect.

According to the invention, the web W2 is stabilized by the web stabilizer 50
in a plane slightly lower than the plane at which it is stabilized over the
slit 29, as seen in FIG. 3. This is because the surface 54 is slightly lower
than the surface 25 above the nozzle 29, and permits the web W2 to be drawn

downwardly with the **Coanda** air flow over surface 25 to a greater degree without over-stressing the web. More efficient cleaning results without more web W2 breaks.

Meanwhile, a partial vacuum is created in the exhaust plenum 30 by a suitable source of reduced pressure (not shown). Sufficient suction is created to draw a high volume of air into the plenum 30 through the slot 35; a volume which is approximately ten times the volume of scrubber air supplied to the system from the **Coanda** nozzle slit 29. The scrubber air, with its dust and lint load, is sucked into the plenum 30. Because more air is being sucked into the plenum 30 than is supplied as scrubber air, environmental dust and lint from the area and from the detached boundary layer air traveling along the damper housing surface 41, 43 is also drawn into the plenum.

In operation of the system comprising the web cleaners 20 and 120 in a tissue web rewinding machine, air under a pressure is directed out of each **Coanda** nozzle slit 29 and 129 next to the adjacent airfoil surfaces 25 and 125. The thin layer of air created by the resultant jet attaches to the curved surfaces, creating low pressure zones adjacent to each nozzle, which tends to draw the tissue toward those nozzles. The air, traveling at high exit flow velocities of 18,000-34,000 fpm, shears away dust and lint from both surfaces of the multiple-ply web in the rewinding machine.

In utilizing the system and practicing the method of the invention, tests were conducted with the improved **Coanda** effect web cleaners 20 and 120 in the rewinding machine. Two different two ply tissue web compositions were employed, a relatively low dust composition identified as T.sub.2 tissue and a

higher dust composition identified as T.sub.1 tissue. The T.sub.2 tissue was a lightly creped, service and industrial quality tissue. The T.sub.1 tissue was a highly creped, soft, premium-type tissue.

FIG. 4 is a graph which represents the dust and lint found on the web as a result of the afore described examination. For the graph, the count was taken from each of the six fractions reported. These were averaged, yielding the number in the graph. The lines represent values correlated to the loose surface dust and lint present on webs per eight square feet of tissue surface after passing through the rewinding machine and in the hardroll. A higher number would indicate more loose surface dust and lint. The abscissa (X-coordinate) of the graph represents an untreated control web, a vacuum only treated web (no **Coanda** nozzle air), and a series of webs treated with increasing **Coanda** nozzle air pressures (10 inches H.sub.2 O through 80 inches H.sub.2 O). The ordinate (Y-coordinate) of the graph represents loose surface dust and lint counts in total particles.

It will be seen in FIG. 4 that with the normally dustier T.sub.1 tissue web, a 50% reduction in surface particles is achieved from each web surface with a **Coanda** effect system in the rewinder when scrubber air pressure is at 50 inches H.sub.2 O or higher. A count of less than 10,000 loose surface fiber/dust particles remained in the diluted sample, per eight square feet of tissue surface. Relatively little particle removal is achieved with the less soft, low dust tissue T.sub.2. The importance is that with the highly desirable, softer premium tissue, surface dust can be reduced to the level normally associated only with lower quality, service and industrial type tissues by

employing the **Coanda** nozzle effect system in the rewinding machine according to
the method of the invention.

a) directing scrubber gas in a transversely elongated jet from a slit defining
a **Coanda** nozzle so that the jet forms a thin, non-turbulent layer of rapidly
moving gas which moves in a direction opposite to web travel and scrubs the
boundary layer of air and entrained dust and lint, as well as dust and lint
embedded in one surface of the web, away from the one surface of said web;

b) directing said scrubber gas with the air and lint and dust which it has
removed from said one surface of said web to follow a **Coanda** nozzle airfoil
surface adjacent said slit until it reaches and is drawn into an exhaust
plenum;

c) simultaneously directing another transversely elongated jet of scrubber gas
from another slit defining a second **Coanda** nozzle so that it forms a thin,
non-turbulent layer of rapidly moving gas which moves in a direction opposite
to web travel and scrubs the boundary layer of air and entrained dust and lint
as well as dust and lint embedded in the other surface of said web, away from
the other surface of said web; and

d) directing said scrubber gas with the air and lint and dust which it has
removed from said other surface of said web to follow a second **Coanda** nozzle
airfoil surface adjacent said another slit until it reaches and is drawn into
an exhaust plenum.

a) under a pressure of at least 20 inches H.sub.2 O, directing scrubber gas in
a transversely elongated jet from a slit defining a **Coanda** nozzle having a
width of between 0.002 and 0.015 inches so that the jet

forms a thin,
non-turbulent layer of rapidly moving gas which moves in a direction opposite
to web travel and scrubs the boundary layer of air and entrained dust and lint,
as well as dust and lint embedded in the surface of the web, away from one
surface of said web;

b) directing said scrubber gas with the air and lint and dust which it has
removed from said one surface of said web to follow a **Coanda** nozzle airfoil
surface adjacent said slit until it reaches and is drawn into an exhaust
plenum;

c) simultaneously directing another transversely elongated jet of scrubber gas
from another slit defining a second **Coanda** nozzle having a width of between
0.002 and 0.015 inches so that it forms a thin, non-turbulent layer of rapidly
moving gas which moves in a direction opposite to web travel and scrubs the
boundary layer of air and entrained dust and lint, as well as dust and lint
embedded in the surface of said web, away from the other surface of said web;
and

d) directing said scrubber gas with the air and lint and dust which it has
removed from said other surface of said web to follow a second **Coanda** nozzle
airfoil surface adjacent said another slit until it reaches and is drawn into
an exhaust plenum.

a) each of said **Coanda** nozzle slits has a width of about 0.012 inches.

a) stabilizing the web before it reaches each of said **Coanda** nozzle airfoil
surfaces by passing it over two additional airfoil surfaces each of which
corresponds to one of the two **Coanda** nozzle airfoil surfaces.

a) each of said additional two airfoil surfaces is disposed in a plane further
from the web than its corresponding **Coanda** nozzle airfoil surface.

a) drawing more air into each exhaust plenums than is supplied by the
corresponding **Coanda** nozzle.